

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES —Volume 28, 1996

Journal of Bioenergetics and Biomembranes is an international journal devoted to the publication of original research that contributes to fundamental knowledge in the areas of bioenergetics, membranes, and transport. The subspecialties represented include membrane transport, electron transport, ATP synthesis by oxidative or photophosphorylation, muscle contraction, and biomembranes.

EDITOR

Peter L. Pedersen, The Johns Hopkins University School of Medicine, Baltimore, Maryland

EDITORIAL BOARD

William S. Allison, University of California at San Diego, La Jolla, California

Giovanna Ferro-Luzzi Ames, University of California at Berkeley, Berkeley, California

L. Mario Amzel, The Johns Hopkins University School of Medicine, Baltimore, Maryland

June R. Aprille, Tufts University, Medford, Massachusetts

Angelo Azzi, Institut für Biochemie und Molekularbiologie der Universität Bern, Bern, Switzerland

Margaret Baltscheffsky, University of Stockholm, Stockholm, Sweden

Diana S. Beattie, West Virginia University School of Medicine, Morgantown, West Virginia

R. Brian Beechey, University College of Wales, Aberystwyth, Dyfed, Wales

William Brusilow, Wayne State University, Detroit, Michigan

Roderick Capaldi, University of Oregon, Eugene, Oregon

Ernesto Carafoli, Laboratorium für Biochemie (ETH), Zurich, Switzerland

Britton Chance, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania

Peter Coleman, New York University, New York, New York

William A. Cramer, Purdue University, West Lafayette, Indiana

Frederick L. Crane, Purdue University, West Lafayette, Indiana

Richard Cross, State University of New York at Syracuse, Syracuse, New York

David W. Deamer, University of California at Davis, Davis, California

Richard A. Dilley, Purdue University, West Lafayette, Indiana

Joyce Diwan, Rensselaer Polytechnic Institute, Troy, New York

Zdeněk Drahota, Czechoslovak Academy of Sciences, Prague, Czech Republic

Lars Ernster, University of Stockholm, Stockholm, Sweden

Shelagh Ferguson-Miller, Michigan State University, East Lansing, Michigan

Robert Fillingame, University of Wisconsin, Madison, Wisconsin

Sidney Fleischer, Vanderbilt University, Nashville, Tennessee

Masamitsu Futai, Osaka University, Osaka, Japan

Keith Garlid, Medical College of Ohio, Toledo, Ohio

Robert Gennis, University of Illinois, Urbana, Illinois

Zippora Gromet-Elhanan, Weizmann Institute of Science, Rehovot, Israel

Richard Hansford, National Institute of Aging, Baltimore, Maryland

Youssef Hatifi, Scripps Clinic and Research Foundation, La Jolla, California

Richard Henderson, Medical Research Council, Cambridge, England

Peter C. Hinkle, Cornell University, Ithaca, New York

Giuseppe Inesi, University of Maryland Medical School, Baltimore, Maryland

H. Ronald Kaback, University of California at Los Angeles, Los Angeles, California

Jack H. Kaplan, Oregon Health Sciences University, Portland, Oregon

Ronald S. Kaplan, University of South Alabama College of Medicine, Mobile, Alabama

Terry H. Krulwich, Mount Sinai School of Medicine, New York, New York

Kathryn LaNoue, Pennsylvania State University, Hershey, Pennsylvania

Janos K. Lanyi, University of California at Irvine, Irvine, California

C. P. Lee, Wayne State University School of Medicine, Detroit, Michigan

Peter Maloney, The Johns Hopkins University School of Medicine, Baltimore, Maryland

Carmen A. Mannella, New York State Department of Health, Albany, New York

Richard E. McCarty, Johns Hopkins University, Baltimore, Maryland

Evangelos Moudrianakis, Johns Hopkins University, Baltimore, Maryland

Nathan Nelson, Roche Institute of Molecular Biology, Nutley, New Jersey

Tomoko Ohnishi, University of Pennsylvania, Philadelphia, Pennsylvania

Ferdinando Palmieri, Università di Bari, Bari, Italy

Sergio Papa, Università di Bari, Bari, Italy

David S. Perlin, The Public Health Research Institute, New York, New York

Hagai Rottenberg, Hahnemann Medical College, Philadelphia, Pennsylvania

D. Rao Sanadi, Boston Biomedical Research Institute, Boston, Massachusetts

Antonio Scarpa, Case Western Reserve University, Cleveland, Ohio

Günter Schäfer, Medizinische Universität zu Lübeck, Lübeck, Germany

Alan E. Senior, University of Rochester Medical Center, Rochester, New York

Noun Shavit, Ben Gurion University of the Negev, Beer Sheva, Israel

V. P. Skulachev, Moscow State University, Moscow, Russia

Bernard Trumpower, Dartmouth Medical School, Hanover, New Hampshire

Tian Y. Tsong, University of Minnesota, St. Paul, Minnesota

Karel Van Dam, E. C. Slater Institute, Amsterdam, The Netherlands

Pierre Vignais, Centre d'Etudes Nucléaires, Grenoble Cedex, France

John E. Walker, Medical Research Council, Cambridge, England

Martin Wikström, University of Helsinki, Helsinki, Finland

Noreen Williams, State University of New York at Buffalo, Buffalo, New York

Hartmut Wohlrab, Boston Biomedical Research Institute, Boston, Massachusetts

Journal of Bioenergetics and Biomembranes is published bimonthly by Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013. *Journal of Bioenergetics and Biomembranes* is abstracted or indexed in Biological Abstracts, Chemical Abstracts, Current Contents, Excerpta Medica, Index Medicus, Referativnyi Zhurnal, and Science Citation Index. © 1996 Plenum Publishing Corporation. *Journal of Bioenergetics and Biomembranes* participates in the Copyright Clearance Center (CCC) Transactional Reporting Service. The appearance of a code line at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use. However, this consent is given on the condition that the copier pay the flat fee of \$9.50 per copy per article (no additional per-page fees) directly to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, Massachusetts 01923, for all copying not explicitly permitted by Sections 107 or 108 of the U.S. Copyright Law. The CCC is a nonprofit clearinghouse for the payment of photocopying fees by libraries and other users registered with the CCC. Therefore, this consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale, nor to the reprinting of figures, tables, and text excerpts. 0145-479X/96 \$9.50

Advertising inquiries should be addressed to Advertising Sales, Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013—telephone (212) 620-8495 and fax (212) 647-1898.

Subscription inquiries and subscription orders should be addressed to the publisher at Subscription Department, Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013 or faxed to the Subscription Department at its number (212) 807-1047, or may be telephoned to the Subscription Department's Journal Customer Service at (212) 620-8468, -8470, -8472, or -8082. Subscription rates:

Volume 28, 1996 (6 issues) \$325.00 (outside the U.S., \$380.00).

Volume 29, 1997 (6 issues) \$355.00 (outside the U.S., \$415.00).

Periodicals postage paid at New York, N.Y., and at additional mailing offices. Postmaster: Send address changes to *Journal of Bioenergetics and Biomembranes*, Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013.

Printed in the USA.

Journal of Bioenergetics and Biomembranes is published bimonthly by Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013. *Journal of Bioenergetics and Biomembranes* is abstracted or indexed in Biological Abstracts, Chemical Abstracts, Current Contents, Excerpta Medica, Index Medicus, Referativnyi Zhurnal, and Science Citation Index. © 1996 Plenum Publishing Corporation. *Journal of Bioenergetics and Biomembranes* participates in the Copyright Clearance Center (CCC) Transactional Reporting Service. The appearance of a code line at the bottom of the first page of an article in this journal indicates the copyright owner's consent that copies of the article may be made for personal or internal use. However, this consent is given on the condition that the copier pay the flat fee of \$9.50 per copy per article (no additional per-page fees) directly to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, Massachusetts 01923, for all copying not explicitly permitted by Sections 107 or 108 of the U.S. Copyright Law. The CCC is a nonprofit clearinghouse for the payment of photocopying fees by libraries and other users registered with the CCC. Therefore, this consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale, nor to the reprinting of figures, tables, and text excerpts. 0145-479X/96 \$9.50

Advertising inquiries should be addressed to Advertising Sales, Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013—telephone (212) 620-8495 and fax (212) 647-1898.

Subscription inquiries and subscription orders should be addressed to the publisher at Subscription Department, Plenum Publishing Corporation, 233 Spring Street, New York, N.Y. 10013 or faxed to the Subscription Department as its number (212) 807-1047, or may be telephoned to the Subscription Department's Journal Customer Service at (212) 620-8468, -8470, -8472, or -8082.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 1

February 1996

CONTENTS

Minireview Series: Membrane Protein Crystallization

Guest Editor: Janusz M. Sowadski

Introduction: Crystallization of Membrane Proteins—In Need of a New Focus? <i>Janusz M. Sowadski</i>	3
Detergent Binding to Unmyristylated Protein Kinase A—Structural Implications for the Role of Myristate <i>Janusz M. Sowadski, Charles A. Ellis, and Madhusudan</i>	7
Strategies for Crystallizing Membrane Proteins <i>R. Michael Garavito, Daniel Picot, and Patrick J. Loll</i>	13
Engineering the Lac Permease for Purification and Crystallization <i>Gilbert G. Privé and H. Ronald Kaback</i>	29
Production of Crystallizable Fragments of Membrane Proteins <i>Wayne A. Hendrickson</i>	35
High-Level Bacterial Expression of Mitochondrial Transport Proteins <i>Ronald S. Kaplan</i>	41

ORIGINAL ARTICLES

A Role for the Disulfide Bond Spacer Region of the <i>Chlamydomonas reinhardtii</i> Coupling Factor 1 γ -Subunit in Redox Regulation of ATP Synthase <i>Stuart A. Ross, Mike X. Zhang, and Bruce R. Selman</i>	49
Subunit 8 of the <i>Saccharomyces cerevisiae</i> Cytochrome bc_1 Complex Interacts with Succinate–Ubiquinone Reductase Complex <i>Christophe Bruel, Robert Brasseur, and Bernard L. Trumpower</i>	59
Modulation of Matrix Ca^{2+} Content by the ADP/ATP Carrier in Brown Adipose Tissue Mitochondria. Influence of Membrane Lipid Composition <i>Edmundo Chávez, Rafael Moreno-Sánchez, María Eugenia Torres-Marquez, Cecilia Zazueta, Concepción Bravo, Sara Rodríguez-Enriquez, Cecilia García, José S. Rodriguez, and Fedrico Martínez</i>	69
α -Lipoic Acid Dependent Regeneration of Ascorbic Acid from Dehydroascorbic Acid in Rat Liver Mitochondria <i>Dian Peng Xu and William W. Wells</i>	77

Front outside cover: A stereo view of the superimposed images of *E. coli* OmpF porin in two different detergents, as determined by single-crystal neutron diffraction (Pebay-Peyroula *et al.*, 1995). The blue contours are from the detergent ring created by N,N-dimethyldecyllamine-n-oxide (DDAO) and the green contours are from β -OG. Under the conditions of the experiment, only the hydrophobic core of the detergent rings is well visualized while the detergent head groups are not well resolved. In the upper panel a porin trimer is viewed down its molecular 3-fold axis showing the detergent ring extending out from the protein surface (represented by the violet α -carbon skeleton superimposed on the map). In the lower panel the contact surfaces between two porin trimers in the crystal are shown. While the protein–protein contacts are made, the head groups of the detergents, which are not resolved here, but against each other; it is obvious that changes in the detergent structure could disrupt these contact sites. Photographs are courtesy of Drs. P. Timmins and E. Pebay-Peyroula (ILL, Grenoble).

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 2

April 1996

CONTENTS

Minireview Series: Mitochondrial Channels

Series Editor: Carmen Mannella

Mitochondrial Channels Revisited <i>Carmen A. Mannella</i>	89
Is There VDAC in Cell Compartments Other than the Mitochondria? <i>Wei Hong Yu and Michael Forte</i>	93
Characterization and Function of the Mitochondrial Outer Membrane Peptide-Sensitive Channel <i>Jean-Pierre Henry, Philippe Juin, François Vallette, and Michel Thieffry</i>	101
Importance of Mitochondrial Transmembrane Processes in Human Mitochondriopathies <i>Marjan Huizing, Vito DePinto, Wim Ruitenbeek, Frans J. M. Trijbels, Lambert P. van den Heuvel, and Udo Wendel</i>	109
Perspectives on the Mitochondrial Multiple Conductance Channel <i>Kathleen W. Kinnally, Timothy A. Lohret, Maria Luisa Campo, and Carmen A. Mannella</i>	115
Anion Channels of the Inner Membrane of Mammalian and Yeast Mitochondria <i>Cristina Ballarin and M. Catia Sorgato</i>	125
The Permeability Transition Pore as a Mitochondrial Calcium Release Channel: A Critical Appraisal <i>Paolo Bernardi and Valeria Petronilli</i>	131
Permeability Transition Pore of the Inner Mitochondrial Membrane Can Operate in Two Open States with Different Selectivities <i>Sergei A. Novgorodov and Tatyana I. Gudz</i>	139
ATP-Regulated K ⁺ Channel in Mitochondria: Pharmacology and Function <i>Adam Szewczyk, Aneta Czyz, Grażyna Wójcik, Lech Wojtczak, and Maciej J. Nałęcz</i>	147
RESEARCH ARTICLES	
Indications of a Common Folding Pattern for VDAC Channels from All Sources <i>Jinming Song and Marco Colombini</i>	153
Detection of Likely Transmembrane β-Strand Regions in Sequences of Mitochondrial Pore Proteins Using the Gibbs Sampler <i>C. A. Mannella, A. F. Neuwald, and C. E. Lawrence</i>	163
Proteins of Cytosol and Amniotic Fluid Increase the Voltage Dependence of Human Type-1 Porin <i>Martin Heiden, Katja Kroll, Friedrich P. Thünnes, and Norbert Hilschmann</i>	171
The Role of Sterols in the Functional Reconstitution of Water-Soluble Mitochondrial Porins from Plants <i>Francesco Carbonara, Birgit Popp, Angela Schmid, Vito Iacobazzi, Giuseppe Genchi, Ferdinando Palmieri, and Roland Benz</i>	181
The High-Conductance Channels of Yeast Mitochondrial Outer Membranes: A Planar Bilayer Study <i>György Bátóri, Ildikó Szabó, Daniel Wolff, and Mario Zoratti</i>	191
Butylated Hydroxytoluene and Inorganic Phosphate Plus Ca ²⁺ Increase Mitochondrial Permeability via Mutually Exclusive Mechanisms <i>Patricia M. Sokolove and Lisa M. Haley</i>	199
The Mitochondrial Inner Membrane Anion Channel Is Inhibited by DIDS <i>Andrew D. Beavis and Hamid Davatol-Hag</i>	207

Front outside cover, Upper: Schematic representation of ion channels that have been identified in mitochondrial membranes. Acronyms and symbols are defined in article by Mannella starting on page 89. Lower: Three-dimensional structure of a rat-liver mitochondrion obtained by electron tomography (Mannella *et al.*, 1994, *Microscopy Research and Technique* 27:278–283). Each intracristal compartment is indicated by a different color.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 3

June 1996

CONTENTS

Minireview Series: Ion Channels in Plasma Membrane Signal Transduction

Series Editor: William A. Catterall

Introduction: Ion Channels in Plasma Membrane Signal Transduction <i>William A. Catterall</i>	217
Molecular Properties of Sodium and Calcium Channels <i>William A. Catterall</i>	219
Molecular Properties of Voltage-Gated K ⁺ Channels <i>J. Oliver Dolly and David N. Parcej</i>	231
High-Conductance Calcium-Activated Potassium Channels; Structure, Pharmacology, and Function <i>Gregory J. Kaczorowski, Hans-Günther Knaus, Reid J. Leonard, Owen B. McManus, and Maria L. Garcia</i>	255
Molecular Mechanisms of Cyclic Nucleotide-Gated Channels <i>William N. Zagotta</i>	269
ORIGINAL ARTICLES	
Cellular Drug Efflux and Reversal Therapy of Cancer <i>Paul W. Wigler</i>	279
Characterization of the Bifunctional Mitochondrial Processing Peptidase (MPP)/bc ₁ Complex in <i>Spinacia oleracea</i> <i>AnnaCarin Eriksson, Sara Sjöling, and Elzbieta Glaser</i>	285

Front outside cover: Subunit structures of ion channels. Center: A cross-section and an *en face* view of a phospholipid bilayer membrane containing a hypothetical ion channel consisting of four subunits or domains surrounding a central pore, as in the voltage-gated ion channels. Carbohydrate moieties are illustrated as curving lines. Top: The primary structure of the principal subunit of a sodium or calcium channel is illustrated as a transmembrane folding diagram based on analysis of the hydrophobicity of the amino acid sequence. Note the four repeating domains which surround the central pore as illustrated in the drawing in the center. Predicted transmembrane alpha helices are illustrated as cylinders. The remainder of the polypeptide chain is illustrated as a bold line with the length of each segment approximately proportional to the length of its amino acid sequence. Red, the S4 segments that serve as voltage sensors; green, the S5, S6, and P segments that line the pore; yellow, the inactivation gate segment that closes over the intracellular mouth of the pore during inactivation. Left, Right: The primary structures of a voltage-gated potassium channel and a calcium-activated potassium channel, respectively. Note that each is analogous in structure to one domain of a sodium or calcium channel. Color coding is the same as for the drawing at the top.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 2

April 1996

CONTENTS

Minireview Series: Mitochondrial Channels

Series Editor: Carmen Mannella

Mitochondrial Channels Revisited <i>Carmen A. Mannella</i>	89
Is There VDAC in Cell Compartments Other than the Mitochondria? <i>Wei Hong Yu and Michael Forte</i>	93
Characterization and Function of the Mitochondrial Outer Membrane Peptide-Sensitive Channel <i>Jean-Pierre Henry, Philippe Juin, François Vallette, and Michel Thieffry</i>	101
Importance of Mitochondrial Transmembrane Processes in Human Mitochondriopathies <i>Marjan Huizing, Vito DePinto, Wim Ruitenberg, Frans J. M. Trijbels, Lambert P. van den Heuvel, and Udo Wendel</i>	109
Perspectives on the Mitochondrial Multiple Conductance Channel <i>Kathleen W. Kinnally, Timothy A. Lohret, Maria Luisa Campo, and Carmen A. Mannella</i>	115
Anion Channels of the Inner Membrane of Mammalian and Yeast Mitochondria <i>Cristina Ballarin and M. Catia Sorgato</i>	125
The Permeability Transition Pore as a Mitochondrial Calcium Release Channel: A Critical Appraisal <i>Paolo Bernardi and Valeria Petronilli</i>	131
Permeability Transition Pore of the Inner Mitochondrial Membrane Can Operate in Two Open States with Different Selectivities <i>Sergei A. Novgorodov and Tatyana I. Gudz</i>	139
ATP-Regulated K ⁺ Channel in Mitochondria: Pharmacology and Function <i>Adam Szewczyk, Aneta Czyż, Grażyna Wójcik, Lech Wojtczak, and Maciej J. Nalecz</i>	147
RESEARCH ARTICLES	
Indications of a Common Folding Pattern for VDAC Channels from All Sources <i>Jinming Song and Marco Colombini</i>	153
Detection of Likely Transmembrane β-Strand Regions in Sequences of Mitochondrial Pore Proteins Using the Gibbs Sampler <i>C. A. Mannella, A. F. Neuwald, and C. E. Lawrence</i>	163
Proteins of Cytosol and Amniotic Fluid Increase the Voltage Dependence of Human Type-1 Porin <i>Martin Heiden, Katja Kroll, Friedrich P. Thines, and Norbert Hilschmann</i>	171
The Role of Sterols in the Functional Reconstitution of Water-Soluble Mitochondrial Porins from Plants <i>Francesco Carbonara, Birgit Popp, Angela Schmid, Vito Iacobazzi, Giuseppe Genchi, Ferdinando Palmieri, and Roland Benz</i>	181
The High-Conductance Channels of Yeast Mitochondrial Outer Membranes: A Planar Bilayer Study <i>György Báthori, Ildikó Szabó, Daniel Wolff, and Mario Zoratti</i>	191
Butylated Hydroxytoluene and Inorganic Phosphate Plus Ca ²⁺ Increase Mitochondrial Permeability via Mutually Exclusive Mechanisms <i>Patricia M. Sokolove and Lisa M. Haley</i>	199
The Mitochondrial Inner Membrane Anion Channel Is Inhibited by DIDS <i>Andrew D. Beavis and Hamid Davatol-Hag</i>	207

Front outside cover, Upper: Schematic representation of ion channels that have been identified in mitochondrial membranes. Acronyms and symbols are defined in article by Mannella starting on page 89. Lower: Three-dimensional structure of a rat-liver mitochondrion obtained by electron tomography (Mannella et al., 1994, *Microscopy Research and Technique* 27:278–283). Each intracristal compartment is indicated by a different color.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 3

June 1996

CONTENTS

Minireview Series: Ion Channels in Plasma Membrane Signal Transduction

Series Editor: William A. Catterall

Introduction: Ion Channels in Plasma Membrane Signal Transduction <i>William A. Catterall</i>	217
Molecular Properties of Sodium and Calcium Channels <i>William A. Catterall</i>	219
Molecular Properties of Voltage-Gated K ⁺ Channels <i>J. Oliver Dolly and David N. Parcej</i>	231
High-Conductance Calcium-Activated Potassium Channels; Structure, Pharmacology, and Function <i>Gregory J. Kaczorowski, Hans-Günther Knaus, Reid J. Leonard, Owen B. McManus, and Maria L. Garcia</i>	255
Molecular Mechanisms of Cyclic Nucleotide-Gated Channels <i>William N. Zagotta</i>	269
ORIGINAL ARTICLES	
Cellular Drug Efflux and Reversal Therapy of Cancer <i>Paul W. Wigler</i>	279
Characterization of the Bifunctional Mitochondrial Processing Peptidase (MPP)/bc ₁ Complex in <i>Spinacia oleracea</i> <i>AnnaCarin Eriksson, Sara Sjöling, and Elzbieta Glaser</i>	285

Front outside cover: Subunit structures of ion channels. *Center:* A cross-section and an *en face* view of a phospholipid bilayer membrane containing a hypothetical ion channel consisting of four subunits or domains surrounding a central pore, as in the voltage-gated ion channels. Carbohydrate moieties are illustrated as curving lines. *Top:* The primary structure of the principal subunit of a sodium or calcium channel is illustrated as a transmembrane folding diagram based on analysis of the hydrophobicity of the amino acid sequence. Note the four repeating domains which surround the central pore as illustrated in the drawing in the *center*. Predicted transmembrane alpha helices are illustrated as cylinders. The remainder of the polypeptide chain is illustrated as a bold line with the length of each segment approximately proportional to the length of its amino acid sequence. Red, the S4 segments that serve as voltage sensors; green, the S5, S6, and P segments that line the pore; yellow, the inactivation gate segment that closes over the intracellular mouth of the pore during inactivation. *Left, Right:* The primary structures of a voltage-gated potassium channel and a calcium-activated potassium channel, respectively. Note that each is analogous in structure to one domain of a sodium or calcium channel. Color coding is the same as for the drawing at the top.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 4

August 1996

CONTENTS

Minireview Series: Gap Junction Membrane Channels

Series Editor: Gina E. Sosinsky

Introduction <i>Gina E. Sosinsky</i>	295
Molecular Organization of Gap Junction Membrane Channels <i>Gina E. Sosinsky</i>	297
The Life Cycle of a Connexin: Gap Junction Formation, Removal, and Degradation <i>Dale W. Laird</i>	311
Connexin Expression Systems: To What Extent Do They Reflect the Situation in the Animal? <i>Klaus Willecke and Sandra Haubrich</i>	319
Size and Selectivity of Gap Junction Channels Formed from Different Connexins <i>Richard D. Veenstra</i>	327
Multiple Connexin Proteins in Single Intercellular Channels: Connexin Compatibility and Functional Consequences <i>Thomas W. White and Roberto Bruzzone</i>	339
Gap Junctions in Excitable Cells <i>Peter R. Brink, Kerry Cronin, and S. V. Ramanan</i>	351
Regulation of Connexin43 Function by Activated Tyrosine Protein Kinases <i>Alan F. Lau, Wendy E. Kurata, Martha Y. Kanemitsu, Lenora W. M. Loo, Bonnie J. Warn-Cramer, Walter Eckhart, and Paul D. Lampe</i>	359
The Role of Gap Junction Membrane Channels in Secretion and Hormonal Action <i>Paolo Meda</i>	369
The Role of Gap Junction Membrane Channels in Development <i>Cecilia W. Lo</i>	379

Front outside cover: Schematic illustration of gap junction structure overlaid on a filtered image of frozen-hydrated connexons (see Fig. 1 in the article by Sosinsky for an explanation of the illustration). The original micrograph of a crystalline single connexon layer can be seen in Ghoshroy *et al.* (1995). *J. Membr. Biol.* 146:15–28. The filtered image was obtained computationally by applying both a band pass filter and a periodic mask made with the crystal lattice parameters to its Fourier transform. In this image, protein is displayed black, ice as white, and the membrane between the connexon is displayed as gray. The connexons appear as dark hexagonally-shaped units.

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 5

October 1996

CONTENTS

Minireview Series: ATP Synthase: Current Views About Subunit Movements During Catalysis

Series Editor: Peter L. Pedersen

Frontiers in ATP Synthase Research: Understanding the Relationship Between Subunit Movements and ATP Synthesis <i>Peter L. Pedersen</i>	389
Structural Changes in the γ and ϵ Subunits of the <i>Escherichia coli</i> F ₁ F ₀ -type ATPase During Energy Coupling <i>Roderick A. Capaldi, Robert Aggeler, Stephan Wilkens, and Gerhard Grüber</i>	397
Subunit Rotation in F ₀ F ₁ -ATP Synthases as a Means of Coupling Proton Transport Through F ₀ to the Binding Changes in F ₁ <i>Richard L. Cross and Thomas M. Duncan</i>	403
Conformational Transmission in ATP Synthase During Catalysis: Search for Large Structural Changes <i>Masamitsu Futai and Hiroshi Omote</i>	409
The Coupling of the Relative Movement of the a and c Subunits of the F ₀ to the Conformational Changes in the F ₁ -ATPase <i>Susan M. Howitt, Andrew J. W. Rodgers, Lyndall P. Hatch, Frank Gibson, and Graeme B. Cox</i>	415
The Energy Transmission in ATP Synthase: From the γ -c Rotor to the $\alpha_3\beta_3$ Oligomer Fixed by OSCP-b Stator via the β DELSEED Sequence <i>Yasuo Kagawa and Toshiro Hamamoto</i>	421
Does the γ Subunit Move to an Abortive Position for ATP Hydrolysis when the F ₁ *-ADP-Mg Complex Isomerizes to the Inactive F ₁ -ADP-Mg Complex? <i>William S. Allison, Jean-Michel Jault, Chao Dou, and Neil B. Grodsky</i>	433
Subunit Movement During Catalysis by F ₁ -F ₀ -ATP Synthases <i>Jeanne G. Digel, Kendra E. Hightower, and Richard E. McCarty</i>	439
The Chloroplast ATP Synthase: Structural Changes During Catalysis <i>Mark L. Richter and Fei Gao</i>	443
Molecular Switch of F ₀ F ₁ -ATP Synthase, G-Protein, and Other ATP-Driven Enzymes <i>Hiroyuki Noji, Toyoki Amano, and Masasuke Yoshida</i>	451

Front outside cover: Schematic of the *E. coli* ATP synthase depicting the arrangement of the ϵ subunit within the stalk region (see Capaldi et al., this issue).

JOURNAL OF BIOENERGETICS AND BIOMEMBRANES

Volume 28, Number 6

December 1996

CONTENTS

RESEARCH ARTICLES

Reconstituted Cl⁻ Pump Protein: A Novel Ion (Cl⁻)-Motive ATPase 459
George A. Gerencser and Karnam R. Purushotham

Modification of Domains of α and β Subunits of F₁-ATPase from the Thermophilic Bacterium PS3, in Their Isolated and Associated Forms, by 3'-O-(4-Benzoyl)benzoyl Adenosine 5'-Triphosphate (BzATP) 471
Dudy Bar-Zvi, Masasuke Yoshida, and Noun Shavit

Calcium Binding to the Subunit c of *E. coli* ATP-Synthase and Possible Functional Implications in Energy Coupling 483
Stanislav D. Zakharov, Xia Li, Taya P. Red'ko, and Richard A. Dilley

A Flash-Photolysis Study of the Reactions of a *caa₃*-Type Cytochrome Oxidase with Dioxygen and Carbon Monoxide 495
Shun Hirota, Margareta Svensson-Ek, Pia Ädelroth, Nobuhito Sone, Thomas Nilsson, Bo G. Malmström, and Peter Brzezinski

Functional Reconstitution of Photosystem I Reaction Center from Cyanobacterium *Synechocystis* sp PCC6803 into Liposomes Using a New Reconstitution Procedure 503
Josep Cladera, Jean-Louis Rigaud, Hervé Bottin, and Mireia Duñach

Electrogenicity at the Donor/Acceptor Sides of Cyanobacterial Photosystem I 517
M. D. Mamedov, R. M. Gadzhieva, K. N. Gourovskaya, L. A. Drachev, and A. Yu. Semenov

The Irreversibility of Inner Mitochondrial Membrane Permeabilization by Ca²⁺ plus Prooxidants Is Determined by the Extent of Membrane Protein Thiol Cross-Linking 523
Roger F. Castilho, Alicia J. Kowaltowski, and Anibal E. Vercesi

Effectors of the Mammalian Plasma Membrane NADH-Oxidoreductase System. Short-Chain Ubiquinone Analogues as Potent Stimulators 531
François Vaillant, Jari A. Larm, Gabrielle L. McMullen, Ernst J. Woltvetang, and Alfons Lawen

MINIREVIEW

Altered Drug Translocation Mediated by the MDR Protein: Direct, Indirect, or Both? 541
Paul D. Roepe, LiYong Wei, Mary M. Hoffman, and Friederike Fritz

Front outside cover: Working model of the Cl⁻-stimulated, Cl⁻-translocating ATPase, or Cl⁻ pump (see Gerencser and Purushotham, this issue).